

East Midlands Regional Group meeting reports 2009

The 3D Visualisation of the River Thames Terraces

Meeting at British Geological Survey, Keyworth, Notts on 21 January 2009

Report by Helen Burke and Vanessa Banks

At just an hour's notice Helen Burke stood in for Holger Kessler, with a presentation that exemplifies the BGS 3D geological modelling capability. Within the Thames region there have been two models carried out: the first was a 1:10 000 scale model of the Thames Gateway area and the second a regional model of the London area, covering 2,400 km² modelled at 1: 50 000 scale. The London model was divided into six tiles to approach the work, which have been combined into a single 3D model of the area.

Using a digital terrain model, geological map and borehole logs (entered into an Oracle database), 3D models are created by constructing a series of intersecting cross-sections, composed of correlation lines between boreholes. The cross-sections form the basis for 'envelopes', comprising the outcrop and subcrop of each geological unit in the model. These aspects of the modelling are all done manually. The only automated part is the calculation of gridded surfaces volumes. The modeller can edit and refine the model by modifying the cross-sections, such as by adding nodes or new borehole records and adjusting envelope boundaries.

Helen showed us how 3D modelling has been applied to the visualisation of the middle Pleistocene Thames Terraces. The River Terrace Deposits form a series of benches along valley sides, which become progressively younger towards the river. The envelopes of specific gravels, for example the Boyn Hill Gravel Formation, or the Lynch Hill Gravel Formation, which appear as ribbons in the 3D model, can be selected and studied. This modelling has facilitated the regional correlation of river terraces between catchments. Additional work has been carried out on the integration of the London and Thames Gateway models. Bedrock geology mapping has also been integrated with GSI 3D software in the London model. Helen pointed out that the advantages of the 3D geological model include visualising concealed deposits and the calculation of volumes and surfaces. A facility within the BGS modelling programme (GSI 3D) is the opportunity to generate synthetic sections along any profile, thereby enabling inspection of lateral profiles at any orientation.

The presentation, held in the BGS 3D Immersive Visualisation Suite, was followed by a short demonstration of some of BGS' visualisation capability. The demonstration started with the Subsurface Viewer, one format that BGS uses to supply 3D models to clients, or to the public via its website. The Subsurface Viewer is a relatively powerful application in that synthetic borehole logs and cross sections can be created by the user; exploded views of the models can be examined; and attributed models can be viewed in a variety of ways, e.g. engineering properties, permeability etc. This was followed with a demonstration of the most recent of the modelling packages that has been acquired by the BGS:

the Geovisionary modelling platform. This can be used for remote field reconnaissance work, where mapped geological lines can be checked against topographic features and field work can be targeted accordingly. A very powerful tool, this platform supports a high resolution DTM and enables the user to “fly” through the landscape, in three dimensions, to examine particular features (topographical, lithological, or structural) at a given location.

A vote of thanks was given by Geoffrey Jago, who recounted how much our presentation of geology has moved on in the last 50 years.

Geological and Hydrogeological Modelling in the Midlands

Meeting at British Geological Survey, Keyworth on 18 February 2009

Report by Geoffrey Jago

Our speaker at British Geological Survey, Keyworth on 18 February, 2009 was Dr Martin Shepley, Senior Technical Specialist at the Environment Agency, who spoke on the uses of aquifers, and the methods and problems involved in their management across the Midlands.

The Study Area

The main abstraction areas lie in Shropshire in the west, Nottinghamshire in the east and south through Leicestershire to Warwickshire and Worcestershire. In this area the Permo-Triassic rocks, mainly the Sherwood Sandstone, hold the lion's share of potable groundwater.

The 1963 Act

The 1963 Water Resource Act gave rise to a massive task in issuing licences for more than 10 million cubic metres of water a day in England and Wales, a task made no easier by the fact that the effect on the environment was not taken as the first priority when the Bill was drawn up.

Modelling Technique

The Environment Agency uses modern computer techniques to study the extent of water resources and their best conservancy, which depends upon the collection of hydrogeological data. Original groundwater models are enhanced by geological models.

A graph was shown of the abstraction history since 1850 of four aquifers: East Midlands, West Midlands Worfe, Lichfield and East Shropshire, but there was no extensive monitoring before 1970. Studies of the River Maun and the Dover Beck in Nottinghamshire were explained with diagrams. This part of England has a problem with a depreciation of surface water features in the Permo-Triassic sandstone. The

original headwaters of several watercourses have remained dry for many decades.

Regional groundwater and geological computer models apply algorithms the better to understand the head-and-flow and time-variant-climatic sequences in a given aquifer which can be calibrated against historic data. A current study of all the principal aquifers with significant abstraction from the Permo-Triassic sandstone, begun in 2001, is due to be completed in 2009.

Examples of models of specific aquifers were shown and some of the difficulties explained. All have diverse characteristics. For example the effect of superficial deposits, the varying drawdown pattern around wells, the effect of boundary faults, some leaky, the effect of evaporite beds and variable rainfall.

Conclusions

Geological models contribute to groundwater model refinement. Hydrogeological data are necessary, with results from groundwater counterparts providing clues. The Midlands Regional groundwater programme has already provided many benefits.

On Tap

When your correspondent turns a tap in future he will remember the valuable expertise provided by the Environment Agency in maintaining our water reserves and the contribution they make to the excellent quality of Midlands water.

A speech of thanks was given by Dr Andrew Hughes (Groundwater modelling Team Leader at BGS).

Ground Stabilisation: A Holistic Approach to Chalk Mine Treatment

Meeting at Loughborough University on 9 March 2009

Report by Geoffrey Jago

In 1937 a development of 100 houses and a school began at Briars Lane, Hatfield 30 Km north of London. By 1978 it was clear that the ground was less stable than expected, dramatically confirmed in 2001 when a six metre hole abruptly revealed that an earlier developer had been working an extensive chalk mine not far beneath the surface. What was to be done?

The solution was explained to us on 9 March, 2009 at Loughborough University at a joint meeting between the East Midlands Geotechnical Group and East Midlands Regional Group. In a clear exposition, Christopher Milne and Andrew O'Donovan of BAM Ritchies Ltd described how the problem was tackled and solved in co-operation with Hyder Consulting UK Ltd and Ground Solutions Ltd.

A Severe Problem

The bedrock at Briars Lane is Upper Chalk overlain by glacial clays and gravels. Until 1920 the chalk had been dug out in short, very irregular, galleries typically 2m wide by 3.5m high on four levels, none deeper than 21 metres. The problem raised a high public and political profile. It was clearly necessary both to ensure safe occupation of the site by minimising future ground movement and to restore public confidence in the site. Likewise it was vital to demonstrate to all affected parties, not least the residents, that action is being taken. Convened meetings included the local authorities, the public utilities, the highways authority and the emergency services; and exigency plans were drawn up on how to deal with any crisis that arose.

Tackling the Job

The methods used to define the risk strategies and work plans were listed in detail, making it clear that all avenues had been meticulously explored. Many boreholes revealed the positions and volumes of the voids so that their effect upon stability could be assessed. Auger drills were chosen for their low dust and noise, and they were surrounded by transportable fencing to reduce disturbance. Cameras lowered into boreholes revealed clear images showing not only axial views but sideways into the voids; and we were shown a typical movie. Information from vertical holes was augmented by that from trial pits; and inclined holes probed beneath buildings.

Pumping Grout

With contractors involved at an early stage, suitable treatment was devised using relatively uncommon techniques. The basic method was to mix grout on site, using limestone dust as fill, and pump it under pressure of up to 10 bar down 650 vertical holes placed nominally on a three-metre grid. The grout was metered as it went in by volume and flow rate. To avoid the pressurised grout resurfacing, an inflatable sleeve surrounded the lowest section of the delivery pipe to provide a seal.

A resident who was told that the ground beneath her house alone had absorbed 350 cubic metres received the news with such cool aplomb that it appeared the figure had not sunk in as effectively as the grout.

Holistic Approach - Validation and Explanation

Our speakers listed the very many steps taken in the whole process from initiation to satisfactory completion, showing a thoroughly meticulous process covering every aspect, both politically and physically. It was, in fact, a valuable model of how to tackle any engineering problem.

To ensure a competent completion, 251 dynamic probes were sunk, in the later stages, to validate the work. Validation reports were made sectionally during the course of the work, as were summaries for homeowners and insurance companies.

Three-dimensional diagrams clearly expounded each phase of the operation in a way understandable to professionals and laymen alike.

Concluding

In making his final points, Chris Milne said that the key to such work is an experienced contractor, while constructive co-operation must allow flexibility during the course of the operation. In essence mutual confidence is the key to high quality work.

Giving a speech of thanks, Martin Culshaw paid tribute to a very interesting exposition of a thorough operation.

The Impact of Pyrite Oxidation on Building Development

Meeting at University of Derby on 18 March 2009

Report by Geoffrey Jago

“Money is the root of all evil” sang a mid-twentieth century crooner, misquoting St. Paul when he wrote to Timothy, “The love of money is the root of all evil”. Sam Butler added that the want of money is pretty baleful for that matter. On 18th March, 2009 at Derby University we learnt that, at least for the construction industry, the root of all evil is sulphide oxidation.

Mourice Czerewko, Principal Engineering Geologist with Scott Wilson Ltd. explained how the changes that occur in certain common minerals, when the rocks in which they lie are disturbed, can present hefty problems to builders, earth movers and construction engineers. Fool’s gold, real name pyrite, simple iron sulphide, is the prime culprit although gypsum, calcium sulphate, is also well featured in the rogues gallery.

The Pyrite Menace

A major evil pinned on pyrite is how it degrades concrete, if inadvertently included in the mix. Equally, however, it degrades the ubiquitous mudrocks which make up sixty percent of near surface geology when man digs them over and lets the air in. The term mudrock includes mudstones, clays, muds, calcareous mudstone, and clay hardened by compaction and cementation.

During mudrock deposition, anaerobic bacteria eating organics in marine or brackish water produce the pyrite, and it is found in rocks of all ages from Cambrian right through to glacial.

Most rock-forming minerals are stable; but pyrite differs because, when atmospheric moisture and oxygen get in, it decomposes to produce sulphuric acid which then attacks the clay minerals to their degradation. Acid production happens rapidly, a phenomenon brought home to our speaker when a pyritic field

specimen he put in his trouser pocket became sufficiently acidic to cause skin irritation within a couple of hours.

Engineering Properties

The changes to the engineering properties of rocks wrought by their disturbance are many, all explained in detail by our speaker. Natural slaking by the atmosphere, chemical oxidation and, alongside pyrite decomposition, solution of carbonates, sulphates and sulphides all play a part in bringing about textural changes. Black shale, firm when excavated, often crumbles within weeks in the air.

The yellowish secondary potassium iron sulphate, jarosite, is formed from the sulphate minerals gypsum, anhydrite and selenite.

Severe damage to building can be caused by these processes which may start slowly and speed up with the help of bacteria. Brown deposits seen on concrete are often associated with pyrite-derived SO₄ radical. Mudrock fill can break down to a plastic constituency, reducing the competency of slopes by rapid desiccation.

Illustrations

We were shown several pictures relating to problems: ground subsidence near Ripon, Yorkshire, caused by gypsum solution, ochreous effluent from a flooded mine, iron staining of rock exposures, heave in housing in shale which had been previously burnt in a fiery colliery waste tip. The Mam Tor landslip in Derbyshire (twice included in our Group's field excursions), which closed a road, was partly the victim of pyrite in the Edale Shale.

Investigation and Assessment

Scrutiny of a new site begins with a desk study of available information followed by investigation of the ground and materials to be used. Samples are obtained initially from shallow boreholes and trial pits. It is important that samples should be dry. For greater depths, wireline drilling, although costly, affords high quality recovery because the holes are cased. A verified ground model is produced, based upon appropriate logging, testing and specialised analytical procedures to evaluate aggregates and the like. A special tip warned against mistaking white spots in clay for sand - if they are gypsum, expect problems!

Conclusions

In conclusion it was stressed that the effects described were widely encountered wherever earth is moved and buildings constructed. Decomposing pyrite, the solution of minerals and the change in stability of after the weather all profoundly affect repositioned ground. The wise construction engineer will be aware of the merit of expert study.

Following a speech of thanks by Dr. Peter Jones a group of us examined specimens from Maurice's collection including the one that had burnt his leg.

Geology and Extraction of Gypsum and Alabaster in Staffordshire

Meeting at University of Derby on 29 April 2009

Report by Geoffrey Jago

The work of our speaker who rounded off Earth Sciences Careers Day at the University of Derby in a welcome return visit to our Group takes him to the site of a unique wartime event - the largest ever non-nuclear man-made explosion.

Noel Worley of British Gypsum spoke to a gratifyingly large audience on the Fauld Mine and the gypsum and alabaster industry in the Midlands.

The Greeks named them first: gypsos and alabastros indicating that the two minerals have been valued from early times. Formed by evaporation from ancient lakes fed from adjacent seas, calcium sulphate occurs as gypsum, selenite, satin spar, anhydrite and alabaster. All are soft, scale 2 on the Moho scale. The distinctions between the different minerals were explained with the aid of micro-photographs.

The prime mineral of value is gypsum which has been mined in England for over a millennium chiefly because it makes plaster when calcined. Associated alabaster, which finds use for ornaments and tomb monuments, is valued for its attractive appearance, ease of carving and the ability to take a high polish. Plaster moulds used in pottery-making supplied a major contribution to ceramic manufacture not far away at Derby and The Potteries.

Nowadays plaster is mostly derived from coal station desulphurisation so British Gypsum's output is used as a retarder in Portland cement manufacture.

Gypsum is found in recoverable quantities at various places in the Midlands: Chellaston, Gotham, Barrow on Soar, East Leake and Cropwell Butler amongst others; but the Staffordshire deposits are the thicker and it has been mined from underground since 1838 at the Fauld Mine near Tutbury, the largest gypsum mine in Europe. The mineral lies in the Tutbury bed, two to three metres thick, in the upper Triassic Mercia Mudstone. While the seam is primarily gypsum, alabaster occurs in places, often as diapirs - mushroom shaped structures formed after hydration of anhydrite caused it to expand into alabaster, forcing its way into the overlying mudstone. Evidence of this squeezing process is seen in schist-like banding.

At Fauld the Triassic rocks are overlain by up to 40 metres of wet glacial drift, deeply incised by what are probably meltwater channels. Annoyingly for mining work, some deep water-carrying fissures extend down to the mineral bed.

In 1937 the Ministry of Defence took over the mine for use as a munition store. By 1944 it contained 20,000 tons of bombs and howitzer shells. Unexploded bombs which could be recovered were returned to Fauld for reactivation and in November 1944 it is thought that an error in this work was responsible for the explosion of

4000 tons of bombs which removed twelve acres of overburden. The vast crater remains and was the focus of a field excursion by our Group in 2004.

The use of the mine galleries for munitions ceased in 1980 but Fauld Mine continues to thrive despite the working sections having extended to six kilometres from the entrance, the underground journey to work taking half an hour. The time-honoured mining method of pillar and stall is used, relatively wide stall cavities being possible because of a competent roof of gypsum and mudstone.

Formerly mined in large blocks for ornamental use, alabaster, last produced in 1970, is no longer economic to produce, being labour intensive and costly, because explosives which would shatter the mineral are ruled out. The largest blocks mined were eighteen blocks of fifteen tons each, bound for the New York Vanderbilt Museum.

In these times when recycling features daily in the press, it is worth noting that discarded plaster can be usefully regenerated by heating. Certainly plaster on our walls and ceilings is part of our everyday existence, but did you know that you had eaten some today? Small quantities are added to bread to provide calcium and sulphur to improve our diet.

In giving a speech of thanks, Professor Hugh Rollinson paid tribute to the speaker for embracing what geology does best and which makes it so fascinating, by taking us from the micro to the macro and from the molecular and local to a global scale.

Glimpses of the Upper Palaeolithic in the East Midlands

Meeting at British Geological Survey, Keyworth on 18 June 2009

Report by Geoffrey Jago

On 18 June, 2009 at British Geological Survey, Keyworth we were piloted into the geologically recent times of the Stone Age, before Britain was an island, 15,000 to 12,000 years ago. Our speaker was Lynden Cooper of Leicester University Archaeological Services.

During periods when the ice retreated, our ancestors moved north and found a living by water courses, their shelters probably of the “bender” type of tent, covered with animal hides. Migrating animal herds including horses and rhino formed their protein diet. Some bones of wild horses bore marks which were probably cut when the marrow was extracted, while other bones appeared to have been scavenged by hyena and wolverine. In these times a river now called the Bytham rose near Stratford upon Avon and wound its way via Melton Mowbray, Witham on the Hill, Shoudham Thorpe, Timworth, Bury St Edmunds and Diss to enter the sea near Yarmouth.

The main evidence of human occupation lies in small slivers of flint, photographs of many of which were displayed. Most were evidently set in handles of bone or

hard wood to provide the animal butchers with knives and scrapers, their originally sharp edges blunted with use. The few round hand axes that have been recovered were shaped either out of flint, where it was available in the more southerly sectors, or from quartzite where no flint was to be found. Of flint flakes of smaller size, the experience of a present-day flint knapper enabled him to put forward a good theory that many flakes were a by-product when the larger flint tools were fashioned. Split bone served to provide needles, pins and projectile heads.

Eight sites at Avington, Gatehampton Farm, Three-Ways Wharf, Springhead, Sproughton, Swaffham Prior, Vale of Pickering and Launde are known as “bruised blade” sites from the type of artefacts discovered. At one site burnt lithics were unearthed, together with some burnt limestone fragments, probably from a hearth.

Flints at Creswell Crags, Nottinghamshire have been linked with similar ones from Cheddar, Somerset, probably sourced from Wessex indicating that a trade existed in these tools.

This interesting talk provided a useful grounding for our Group’s field excursion, planned for August to Creswell Crags, where evidence, including cave paintings, exists of life in early Britain.

A speech of thanks was given by David Bailey.

Visit to Creswell Crags

19 August 2009

Report by Vanessa Banks. Nine members attended.

Ian Wall, Director of the Heritage Trust led our visit. He had responsibility for overseeing the development of the new museum and visitor centre (Architect: OM1, Manchester and Contractor: Tomlinson Derby), which opened in June 2009 and is run by 12 members of staff. The trip from the Visitor Centre to the gorge takes the visitor via some low bluffs (location of caves C22, 23 and C24, which were excavated (archaeological) in the 1980s). One then passes the location of the former Sewage Treatment Works, built in the 1950s and relocated in 2001 to leave an area that can be used for events and picnics.

Ian described the geological context of the site: in the Magnesian Limestone, towards the southern end of the broad arc of Magnesian Limestone that extends down from County Durham and represents the western shoreline of the former Zechstein Sea. Creswell is one of similarly positioned gorges; others include Pleasley and Roche Abbey. During the last cold stage there were ice sheets to the north of Creswell Crags that extended north to Doncaster.

There is evidence of three phases of human interaction at Creswell: Neanderthals, Early Modern and Modern humans. There were prolonged periods of infrequent use.

Based on tool typology (as the dates lie near the limit of radiocarbon dating) the earliest tools that have been found at the site date to 40 to 60 000 BP and are formed from quartzite pebbles (from the Bunter Sandstone) and occasionally flint. A researcher from the USA (Marcia Rochman) has used micro fossils to establish that the flint is derived from South Hampshire. The evidence suggests seasonal movement of people. The dating of these tools coincides with Neanderthals being replaced by/ interbreeding with modern humans. Modern humans were present in Europe from 200 000 BP. The evidence of early modern humans is limited, one of the indicators is the leaf shaped finely crafted flint points. There is no archaeological evidence of humans during the last cold stage and it is assumed that the population migrated south to France, where there was a population expansion. Post 18 000 BP, associated with the warming of the climate, there was an influx of modern humans. Subsequently sea level rose and Britain was cut off. At between 13 000 to 15 000 BP cave art came into use, as did newer blade technology (Creswellia points).

There are a number of caves at the site. Mother Grundy's Parlour was excavated by Victorian Antiquarians in the 1870s. Among the finds were: Neanderthal tools, Hyena bones that had clearly been chewed and Hyena coprolites. There was also a quartzite, Neanderthal hand axe. A sequence of sediments dating back to the Ipswichian was encountered and contained rhino, lion and many other species. In 1924/5 Leslie Armstrong was active at Creswell, particularly in Pinhole Cave with some access to Mother Grundy's Parlour. There is a small area of Cave Art in this cave, which comprises an unidentified banana shaped object.

We visited Robin Hood's Cave (RHC), the largest cave in the gorge. The other caves comprise simple sacks, whereas this cave incorporates four interconnecting passageways. RHC has been a rich archaeological site. It has been suggested that there is a dichotomy in the function of the caves with those to the south being utilised for living and those to the north being used for rituals. It is not clear how much material has built up in the gorge, but it is suspected that RHC was quite elevated, approximately half way up the cliff and sought during the spring and summer. Cut marked hare bones (12 500 radiocarbon years old) have been found in RHC and also in Church Hole and Pinhole Caves. The suggestion is that the Arctic Hare was trapped for coats, as the cut marks do indicate pelt retrieval. The retrieval of smashed horse teeth from Mother Grundy's Cave that had been fractured along the base of the teeth is considered indicative of the opening of the jaw bones for the recovery of bone marrow. The main phase of excavation in RHC was in 1876. Robert Lang carried out a phase of excavation in the 1880s, excavating under the breccias (material that had entered via the Aven) and in the passageways behind the cave and in the western chamber. During the 1980s there were some human remains (a jaw bone) recovered from this area, which was found to be of late Iron Age/ Romano-British age, indicative of the use of the site for funerary activities. There was clear evidence of modern graffiti, dating back to at least 1819. A variety of tools have been found in the cave, including bone needles. Our tour took us down to the lower chamber, upon which Lang had written a short publication on the cold stage faunas that had been identified, including typical Ipswichian species, including hippopotamus and rhinoceros (slender nose species). During the 1980s there was coring in this passage, which extended to 1.7 m below the path level. The Eastern Chamber was also investigated by Lang, but remains

unstable. In 2003 the Rock Art Reconnaissance work identified an engraving, comprising three lines, in a form that is common to European Rock Art. The lines were partially covered by flowstone, thereby facilitating minimum ageing of the art to 13 000 BP.

From RHC we moved on to Church Hole Cave (CHC), which was subject to Victorian excavation. The current visitors' platform in this cave approximates to the upper limit of the excavated deposits from the cave. More recently Paul Pettitt has led a search of the Victorian spoil heaps. This excavation identified that there was a considerable amount of faunal material disposed of, but not much flint (suggesting that the Victorian archaeologists had recognised the importance of this material). Amongst the arisings was a "Nine mens' Morris Board". This cave extends at least 150 m into the gorge side. The Cave Art, the highlight of our visit, was identified in 2003, when a mixed research team was specifically looking for Cave Art potential in Lower Palaeolithic cave sites, including sites in Huddersfield. The deer stag in CHC was evident to all. There are also incisions indicative of bison and auroch and, a farther 30 m down the passage, a long necked bird.

Returning to the Visitor Centre and exhibition area we passed the Duke of Portland's Boathouse, another cave, which was initially excavated by L Armstrong, but was subject to flooding difficulties and encountered very hard travertine.

In response to questions about access to the site Ian explained that there is a balance between protecting the Cave Art and ensuring access to the sites. Accordingly, there is a requirement to provide controlled access to the site. The site is not yet a World Heritage Site, but this is an aim.

A speech of thanks for a very interesting and informative visit was given by your correspondent.

Rock Stability Problems in Opencast Coal Mining

Meeting at British Geological Survey, Keyworth on 14 October 2009

Report by Geoffrey Jago

When large holes are dug in the ground, the surrounding rock and gravity regularly collude to reshape the chasm. A well-attended lecture at BGS, Keyworth on 14 October, 2009 was illustrated with about 100 excellent photographs of situations where, in coal measure rocks, gravity had had its way. In most cases, when things go wrong, matters can be cleared up without too much difficulty but in one major instance a Yorkshire river flooded an opencast mine to the tune of nearly 5000 million gallons.

Our speaker was Jerry Sturman who was Regional Geotechnical Engineer for the Midlands, Lancashire and Yorkshire for seven years during his service with the National Coal Board (later British Coal), Opencast Executive.

The Work of the Opencast Executive

The task of NCB/BC was to prove and calculate opencastable coal resources and to complete all necessary procedures for obtaining government authorisation for mining before instituting production contracts with opencast mining contractors. It had a design function with respect to resource assessment and stability, the two being inextricably linked; and in supervising contracts it had to optimise production whilst ensuring stability and promoting health and safety.

Opencast site Planning

Site planning generally allowed for excavation slopes of 1:2 or 1:3 in superficial glacial or alluvial deposits and 1:1 in coal measures although, owing to jointing and bedding plane characteristics, the latter slopes were often steeper in practice. Also, contractors regularly sought opportunities to gain extra coal at lower cost by excavating at steeper slopes and in these cases agreement was reached by negotiation.

Digging the Coal Measures

Coal overburden comprises mudstones, siltstones and sandstones, and coal is underlain in almost all cases by the fossil soils known as seatearths, the high clay content of which tends to make them slippery. The influence of the latter, in combination with jointing and bedding plane anomalies in the overburden is often the key to the way the rocks will behave when disturbed. In addition folding, faulting and especially drag faulting can have major effects on stability, anomalies that are very difficult to identify in exploratory drilling. When excavations approach such features and the dip of strata exceeds 16 degrees the likelihood of failure along seatearth base planes is considerably increased.

Dealing with Spoil

Excavated spoil is placed, where possible, into areas exhausted of coal where, inherently loose, it rests at its natural angle of repose and usually on seatearth. Over time the behaviour of such heaps can change and, especially where there is a slippery seatearth base, the engineer must be wary of instability.

Time, Risk, Health and Safety

The photographic illustrations we were shown ranged from minor rock falls caused by interacting joint planes to major failure from weakness in joint or fault planes or seatearth horizons. Generally difficult to predict and often happening instantaneously, the minor failures are those most likely to endanger personnel. Larger scale failures often manifest themselves by telltale ground cracking, so, to minimise danger to personnel, monitoring is required to make firm operational decisions.

Mining must maintain a balance between speed of production and maintenance of stability while all the time the materials may be deteriorating in condition.

Disturbance of this balance results in delay and increased costs, and hence good cooperation between the supervising engineer and the contractor is essential. Such sound cooperation avoided loss of life and minimised damage to property.

A Valuable Photographic Archive

All of the anomalies were well illustrated in the very comprehensive range of photographs, and Jerry is cooperating with our friends in British Geological Survey so that this aspect of his work can be preserved.

In giving a speech of thanks, your correspondent (an erstwhile working colleague of Jerry's) paid tribute firstly to his pioneering work with the Institution of Geologists which led on to Chartership, and secondly to the work of the NCB / British Coal Opencast Executive which, together with their civil engineering associates (a cooperation to be commended - the profit motives of private enterprise supervised by temperate government management) produced countless quantities of indigenous fuel while making a whacking profit for the coal owner (Britain), and was instrumental in restoring to agriculture (at nil cost to the taxpayer) many thousands of acres of pre-war mining dereliction across the exposed coalfields. Moreover the Opencast Executive led the way worldwide in the field of improving and perfecting land restoration.

William Smith and the New Art of Mineral Surveying

Meeting at British Geological Survey, Keyworth on 16 December 2009

Report by Geoffrey Jago

Once in a blue moon a mastermind emerges whose insight and hard work uncovers a fundamental truth upon which a multitude of disciplines can be constructed. Such a one was William Smith, so-called "father of English geology", and the subject of our Christmas lecture.

On 16 December 2009, at BGS Keyworth, our speaker was distinguished palaeontologist and authority on the history of geology, Professor Hugh Torrens, Emeritus Professor, Keele University.

Smith is celebrated for his extraordinary gifts and energy in seeking out original data and for his ability to work out the vital conclusions, which gave birth to much of modern-day geology. Stratigraphy, structure and the relevance of fossils were his mother wit which he put to good use to define and publish his astonishingly detailed geological map of the greater part of Britain.

The Need for Historical Accuracy

Early in his presentation, in stressing the need for historical accuracy, Professor Torrens said that Smith had attracted the attention of number of recent popular biographers not all of whom, regrettably, had checked their facts. Despite Smith

being an honourable man, biographers had wrongly accused him of dishonesty and, of his wife, even nymphomania which could then mean so many things, beside its modern meaning. One biographer, indeed, showed an uncanny grasp of both geology and history by stating that Smith had assisted New Forest charcoal burners with a rock-drilling programme to prove underground reserves of both non-existent, and un-needed, coal.

Smith's Practical Work

How can we honour Smith? He was so ahead of his time that the word 'geology' was barely in use. Rather than calling himself a geologist, he preferred the terms engineer, mineralogist and mineral surveyor. The latter - newly coined - meant one who sought stratified minerals like coal, limestone or brickearths, subsurface.

Travelling by coach, horse and foot, in some years he covered over 10,000 miles - more than many of us now motor on smooth tarmac. He started as a land surveyor, and progressed to canal engineering, land draining, coastal land recovery in East Anglia, (sea breaching) and mineral prospecting. Well acquainted with and working for rich landowning peers, he was skilful in gaining political although not financial patronage.

Rock exposures during canal excavations first revealed the similarity between particular strata in different locations. Fossil collecting was a common hobby but it took the intelligence of Smith to realise how fossils labelled each horizon. This led to his fathering scientific biostratigraphy and then, by his cross-sectional diagrams, he was the first to explain the whole geological structure of England.

Hard Times

Smith's working years were not easy times. Britain was at war for much of the time and honest people whose credit ran out could be imprisoned. A fate happily not in vogue in 21st century England but which befell the hapless Smith for nearly ten weeks when his support evaporated in 1819. This may have led some modern writers to level accusations of dishonesty but Smith was meticulously honest in paying his debts unlike the cavalier attitude of so many of his debtors.

Smith the Prospector

From 1801, Smith, aged 32, began mineral prospecting, mainly for coal, which he called "by far the most valuable part of my work". The burgeoning industrial revolution and the deprivations of Napoleonic wars fostered an increasing hunger for coal, which encouraged investors into drilling and shaft sinking adventures. Many lost money by determined penetration of likely looking dark clays thought to be coal measures, but which in fact turned out to be the likes of the Lower Lias or Oxford Clay. Some avid investors, sometimes encouraged by less than honest shaft-sinkers, still did not realise their costly mistake, even after 300 metres. While guiding prospectors to fruitful research, Smith equally tried to warn others away from hopeless projects but good advice could go unheeded with investors who had a drill bit between their teeth.

Final Recognition

It is further to Smith's credit that he was able to make the truth of his science prevail against the resolute ignorance of many of his richer and better educated contemporaries, not least some of those who coalesced into the Geological Society in 1807.

His famous geological map of England, Wales and part of Scotland was published, together with his geological cross-section by single-handed effort in 1815. Five years later the first president of the Geological Society, George Greenough, distinguished himself by drastically eroding Smith's earnings with his alternative geological map based largely on Smith's work.

After academic rumination for a decade or two, in 1832 the Geological Society recognised the master by awarding him their first Wollaston Medal. Smith was at last a recognised authority during the years until his death aged 70 in 1839.

Acknowledgement

Your correspondent is grateful to Professor Torrens, from whose lecture, together with his written lecture "Timeless Order", published in the book "Memoirs of William Smith LL D by his nephew John Phillips", these notes are derived. This admirable example of historical clarification demonstrates the value of deriving fact from original data, a practice sadly not always observed by every writer.

The lecture was introduced by John Ludden, Executive Director of BGS, to whom our Group offers thanks for his generous provision of facilities for the majority of our meetings during the year.

A speech of thanks was given by Michael Howe of the BGS National Geoscience Data Centre.